NASA Armstrong Flight Research Center

Dynamics and Controls (530)

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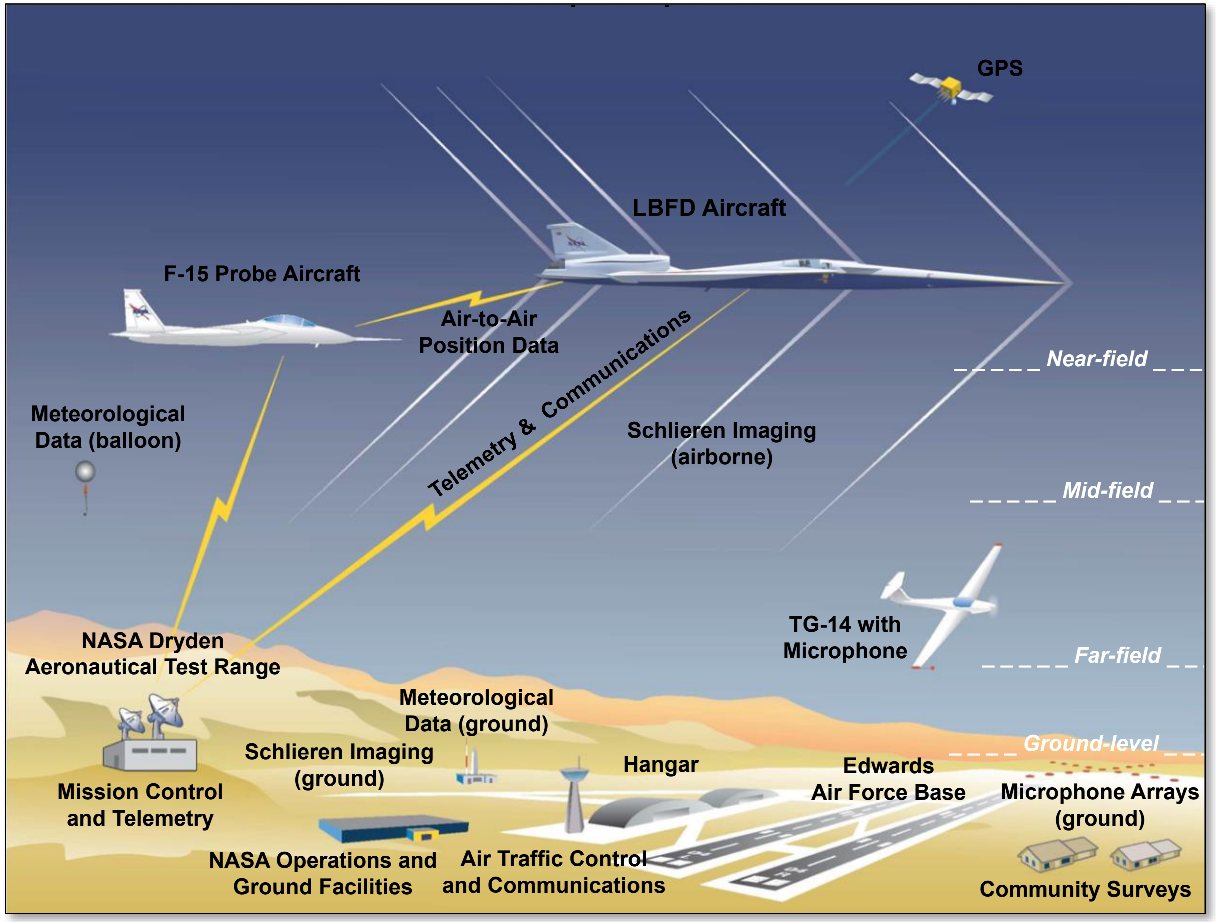
AFRC Controls and Dynamics Branch

- Research Areas:
  - Traditional GN&C
    - Classical and advanced control algorithms
    - Risk based approaches for safety critical applications
    - Integration of novel sensors and sensor fusion (FOSS, LIDAR, etc.)
    - Trajectory optimization and control
  - Flight/System Dynamics
    - Equations of Motion and integrated modeling of vehicles and vehicle systems
    - Unique and novel vehicle dynamics
    - Methods for extracting relevant vehicle dynamic information from flight data
  - Human and vehicle interfaces and interactions
    - Handling Qualities and Pilot-in-the-loop oscillations (PIO) predictions and design metrics
    - Ride quality research
  - Autonomy
    - Novel algorithms, sensors, and sensor fusion
    - Bounding risk for testing automated systems
    - Pilot/Operator interactions
- Engineering Support and Airworthiness Assessments
  - Aircraft modifications and experimental configurations

X-59 Low-Boom Flight Demonstrator

- Program Overview:
  - Phase 1 – Aircraft Development
  - Phase 2 – Acoustic Validation
  - Phase 3 – Community Response
- AFRC Controls and Dynamics Role:
  - Simulation Development- engineering / mission planning / pilot training
  - Independent Assessments: Stability / Handling Qualities
  - Control Challenges
    - Unstable bare airframe in pitch
    - Large Clb, weak Cnb (supersonic)
    - Limited forward vision due to required forward fuselage shape
    - Trade-off between rigid body stability and flexible margin
    - Managing the boom

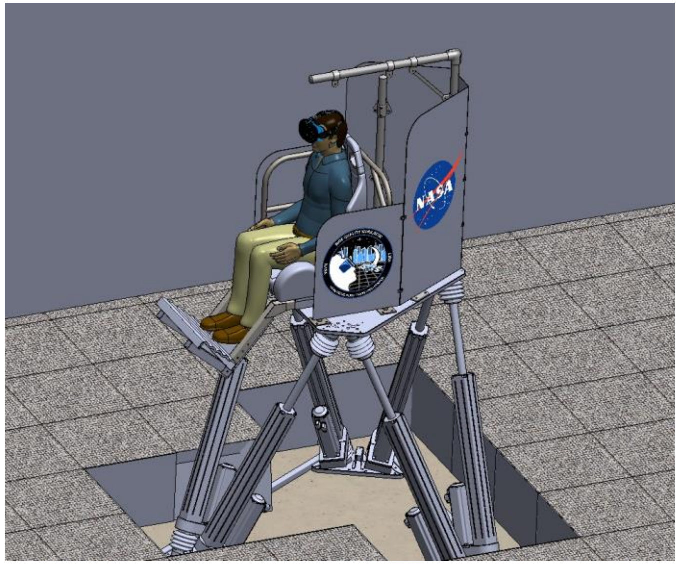


X-57 Maxwell

- Project Overview:
  - Mod II - test the all-new electric propulsion system
    - Significant challenges with components, subsystems, and integration have caused delays
    - Project rescoped to just include Mod II flights
    - Aircraft put in flyable storage after Mod II flights
  - Mod III – high-speed cruise efficiency wing development
    - Subsystem designs complete for Mod III
  - Mod IV – test with the high lift motor system
    - Some high lift subsystems being fabricated and delivered, but no integrated testing planned.
- AFRC Controls and Dynamics Role:
  - Engineering support and airworthiness assessment role
  - Simulation development and use
    - Evaluation of handling qualities effects of changes in mass properties, and with critical failure conditions
    - Pilot training and procedure development

Revolutionary Vertical Lift Technology - RVLT

- RVLT Tech Challenges:
  - Reliable and Efficient Propulsion Components for Urban Air Mobility (UAM)
  - Tools to Explore the Noise and Performance of Multi-Rotor UAM Vehicles
  - Urban Air Mobility (UAM) Operational Fleet Noise Assessment
  - **Acceptable Pilot Handling Qualities (HQ) and Passenger Ride Quality (RQ) for UAM Vehicles**
- AFRC Controls and Dynamics Role:
  - Developing a Ride Quality Simulation facility and experiments to evaluate unique aspects of the UAM mission
  - Evaluating handling qualities with complex powertrain models capable of simulating realistic powertrain failures
  - Control allocation with powertrain constraints
  - Envelope protection control schemes for simplified pilot operations

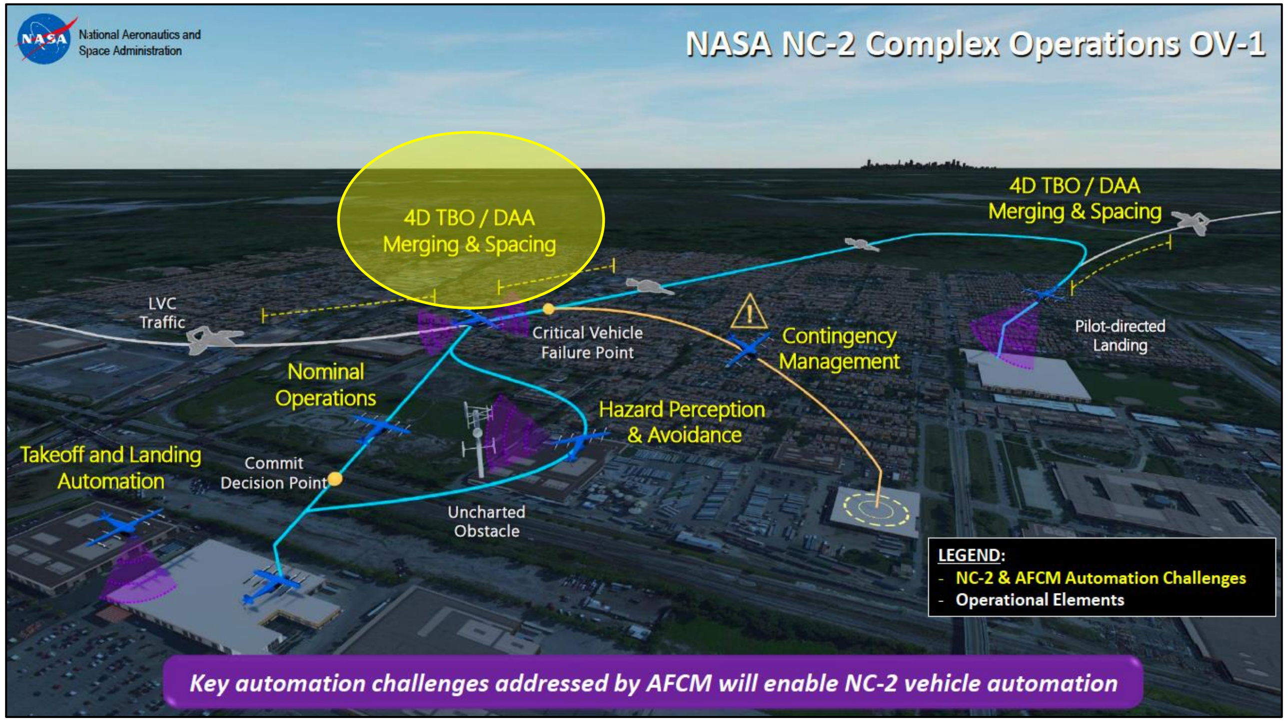


Airborne Instrumentation for Real-world Video of Urban Environments - AIRVUE

- Motivation:
  - To inspire autonomous aviation advances by creating large, diverse, open datasets in an AAM context.
- Project Goals:
  - Build and publish datasets to accelerate autonomy perception research toward UML4+
  - Integrate cameras and other sensors into a ride-along pods and install the pods on fleet helicopters
  - Accumulate and curate the video & sensor data in online repositories accessible to researchers across NASA and beyond
- Approach
  - Developmental testing on NASA aircraft and UAV’s
  - Production pod for eventual deployment on partner vehicles such as LAPD and LA County Fire helicopters

Integration of Automated Systems - IAS

- Objective:
  - To integrate AAM relevant automation technologies and test them in a relevant environment on an appropriate flight platform
- IAS-1
  - Hazard Perception and Avoidance (HPA) – Detect and avoid
    - Based on FAA/Lincoln Labs ACAS-XR
  - Flight Path Management (FPM) – 4D optimal flight trajectories
  - Flight testing to characterize
    - Human factors
    - Navigation performance
  - Test platform Sikorsky Autonomy Research Aircraft (SARA), modified S-76B
- AFRC Controls and Dynamics Role
  - Support integration, flight testing planning, and data analysis
  - Investigate and address some issues that arose in flight due to the integration of the autonomy



SUbsonic Single Aft eNgine Electrofan-SUSAN

- Objectives:
  - To leverage Electrified Aircraft Propulsion (EAP) and Propulsion Airframe Integration (PAI) to reduce emission by 50% while maintaining size, speed, and range of large regional jets.
  - Explore EAP to as an enabler to single engine jet transport operations
- Current Research Efforts
  - Full Scale 180 Passenger Concept - conceptual design of a 20MW class regional transport.
  - 25% Scale Flight Demonstrator - Unpiloted 30 ft span, weight 1500-2000lbs, and power 150-200kW
  - Subscale Unmanned Systems Integration Effort (SUSIE)

- AFRC Controls and Dynamics Role:
  - Full Scale
    - Flight control requirements
    - Piloted simulation evaluation
    - Flight control design and evaluation
  - 25% Flight Research Vehicle
    - Piloted simulation development
    - Vehicle Management System design
    - Flight control design
    - Ground control station and flight operations
  - SUSIE
    - Flight operations
    - System ID
    - Flight control design

Attritable Aircraft for Autonomy Research

- What do we mean by an “attritable” aircraft?
  - A collection of aircraft capabilities where vehicle loss is an acceptable while not expected outcome.
- What should be tested on this type of test bed?
  - High risk technology that needs data to lower risk before testing in a more operational environment
  - When real world data could accelerate the development cycle
  - When the problem permits testing at subscale
- Traditional challenges with this approach:
  - Vehicles not truly attritable → loss of aircraft slowed/stopped research
  - Lack of hardware/software documentation
  - Lack of engineering support
  - Immature software tools
  - Poor quality data not suitable to flight research goals
- Potential Benefits:
  - Enable researchers to implement, evaluate and improve algorithms/software/sensors in a relevant flight environment (SpaceX and CubeSat model)
  - Hardware and software architectures that can scale to multiple platforms
  - Faster design/evaluation cycles through tailored risk and systems engineering approach
  - Workforce development in systems engineering, flight test, controls, and autonomy

Transonic Truss Based Wing - TTBW

- Research Objectives:
  - Increased aerodynamic efficiency to address climate and emissions goals
- AFRC Controls and Dynamics Perspective:
  - Evaluate potential controls challenges in a piloted simulation:
    - Stall properties including deep stall arising from the T-tail configuration
    - High speed buffet, ASE, and control reversal challenges from high aspect ratio thin wings

Conclusions and Questions